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(54) ## Bank note checking apparatus.

(57) A bank note checking apparatus which is used, for example, in an automatic deposit machine and which checks a bank note by comparing patterns read from the bank note (1) with reference patterns includes means (P_1) for reading patterns from a conveyed bill and one or more sensors (T_1, T_2, W_1, W_2) for determining the physical condition of the bank note (1) during conveyance. The apparatus also includes means for generating an appropriate reference pattern from stored standard patterns (9) in accordance with the sensed physical condition of the bank note (1) and means (11) for comparing the patterns read from the bank note (1) by the means (P_1) for reading patterns with the generated reference pattern, thereby determining the validity and/or denomination of the bank note (1). Typically the sensors (T_1, T_2, W_1, W_2) monitor the size of the bank note (1) and its orientation with respect to the means (P_1) for reading the patterns so that the size and any tilt or transverse displacement of the bank note (1) is taken account of in the generation of the reference pattern.

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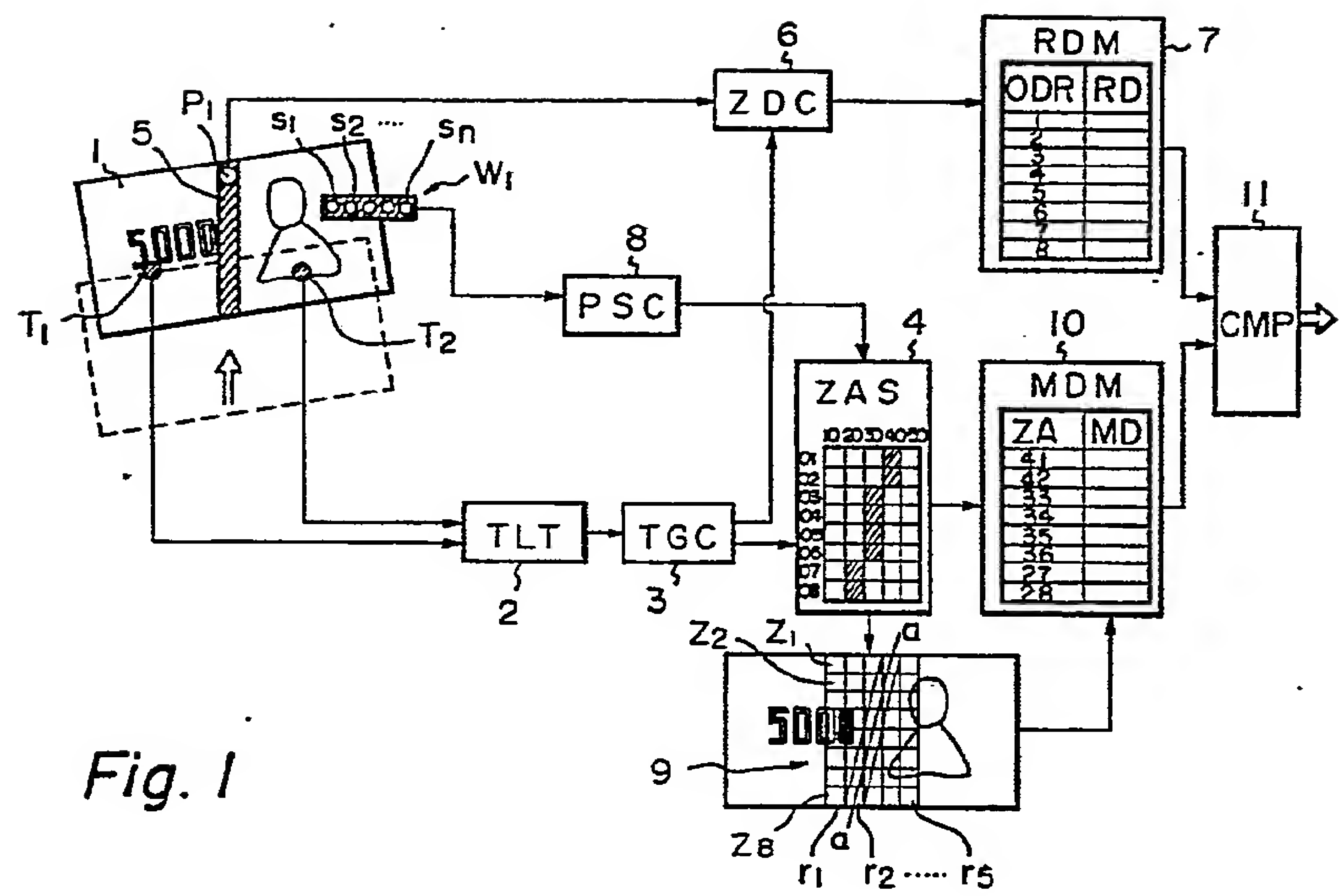

ZDC
RDM
ODR
RD
PSC
ZAS
MDM
ZA
MD
CMP
TLT
TGC
5000
P1
S1
S2
Sn
W1
T1
T2
Z1
Z2
Z8
r1
r2
r5

Fig. 1

BANK NOTE CHECKING APPARATUS

The present invention relates to a bank note checking apparatus for use in a bank note processing system such as an automatic deposit machine which checks a plurality of bank notes that are fed into it and which executes processing depending upon the validity or denomination of the bank notes.

In a conventional bank note checking apparatus used, for example, in an automatic deposit machine, a bank note is conveyed along a passage along which one or more discriminating or validity checking sensors are arranged. The passage includes guides on both sides so that narrow gaps are defined between the guides and the bank note being conveyed and so that the bank note can not tilt or deviate sideways, to maintain the relative position of the bank note and the sensor or sensors constant so that a predetermined pattern region of the bank note is always read by the descriminating or validity checking sensor or sensors. Some allowance, however, must be made for a small degree of deviation. To effect discrimination or validation in spite of the presence of a small degree of deviation, therefore, the bank note must be checked by using regions containing relatively simple patterns. Therefore, it is difficult to carry out checking with a high degree of accuracy, and errors are made depending upon the degree of damage of or contamination of the bank note.

When guides are provided at each side of the passageway any attempt that is made to make the apparatus handle more than one denomination of bank

note increases these problems since the size of bank note usually varies with its denomination and consequently bank notes of small size are even more likely to suffer from deviation and consequently be even more difficult to check. In the case of small size bank notes it is difficult to restrict the position of the bank notes with respect to the sensor or sensors with sufficient accuracy.

If the passage is strictly defined, furthermore, the bill is always conveyed through the same passage no matter how many times the same bill is fed into the apparatus. Consequently in view of the relatively high error rate if a counterfeit bill is continually fed into the machine it is likely to be accepted by the checking portion at some time.

Further, if attempts are made to reduce the error rate by checking complicated patterns of the bank note all of the contents of a reference pattern memory forming part of the apparatus must be read and checked. Therefore, more time is required for the checking process.

According to this invention a banknote checking apparatus comprises means to convey bank notes, means for reading patterns from a bank note as it is conveyed past the means, one or more sensors for determining a physical condition of the bank note during conveyance, means for generating an appropriate reference pattern from stored standard patterns in accordance with the sensed physical condition of the bank note, and means for comparing the patterns read from the bank note by the means for reading patterns with the generated reference patterns, thereby determining the validity and/or the demonination of the bank note.

A particular example of a bank note checking apparatus in accordance with this invention and an automatic deposit machine including such an apparatus will now be described and contrasted with a prior apparatus with reference to the accompanying drawings; in which:-

Figure 1 is a block circuit diagram illustrating the operating principle of the discrimination or validity checking operation performed by the apparatus;

Figure 2 is a side elevation illustrating the internal construction of an automatic deposit machine;

Figure 3 is a side elevation of the gate assembly of the deposit machine;

Figure 4 is a plan of a bank note checking portion of a conventional bank note checking apparatus;

Figure 5 is a plan of a bank note checking portion used in the deposit machine;

Figures 6A and 6B are a plan and a side elevation of a magnetic head assembly used in the deposit machine;

Figures 7A to 7C and Figures 8A and 8B illustrate the structure of a light emitting unit used in the position sensor of the deposit machine;

Figures 9A and 9B illustrate the skew sensor of the deposit machine;

Figures 10A and 10B illustrate the structure of a reflection-type photo-sensor used in the deposit machine;

Figure 11 is a plan of the bank note checking portion;

Figures 12A and 12B are format diagrams illustrating information stored in model maps used in the deposit machine;

Figures 13 and 14 are flow charts showing the operation sequence for determining the tracks of model maps;

Figure 15 is a block circuit diagram of a checking circuit; and,

Figure 16 is a circuit diagram illustrating a zone divider circuit forming part of the checking circuit.

Figure 1 illustrates a principle of the discriminating operation performed by the apparatus according to the present invention. In Figure 1, a bank note 1, hereinafter referred to as a bill is conveyed in the direction of arrow A. Amount-of-tilt sensors T1 and T2, i.e., skew sensors, detect the leading edge and the trailing edge of bill 1. Tilt detection circuit 2 detects the amount of tilt of bill 1 from the time interval between the time when one of sensors T1 and T2 detects the leading edge of bill 1 and the time when the other sensor T1 or T2 detects the leading edge of bill 1. Trigger circuit 3 triggers zone address-selecting circuit 4 and inputs thereto the amount of tilt of bill 1 from tilt detection circuit 2.

Pattern sensor P1 reads the patterns of hatched track region 5 of bill 1. Zone-dividing circuit 6 is triggered by trigger circuit 3 and divides a continuous pattern signal from pattern sensor P1 into a plurality of zone signals each corresponding to a pattern of one of the zones of track region 5 of bill 1. The zone signals are converted into digital read data RD by an A/D converter (not shown) and digital read data RD is memorized in read data memory 7 in the order ODR read by pattern sensor P1.

Position sensor W1 comprises a plurality of sensor elements s1, s2, ..., sn arranged in a direction perpendicular to the transfer direction of bill 1 shown by arrow A or in one or more lines tilted from the transfer direction of bill 1. Position-sensing circuit 8 receives sensor signals from sensor elements s1, s2, ..., sn of position sensor W1 and determines the position of bill 1 in a direction perpendicular to the direction of conveyance of bill 1.

Model map memory 9 memorizes the standard pattern data of all of the zones of a plurality of adjacent tracks r1, r2, ..., rm. In the example of Fig. 1, model map memory 9 memorizes the standard pattern data of five tracks r1, r2, ..., r5, each track being constituted of eight zones Z1, Z2, ..., Z8.

Zone address-selecting circuit 4 generates a series of address data corresponding to the data of the zones of

bill 1 traced and sensed by pattern sensor P1 on the basis of the amount of tilt data from trigger circuit 3 and the position data from position sensing circuit 8. According to the address data from zone address-selecting circuit 4, zone data is read out from model map memory 9 and is stored in model data memory 10 as reference data for that particular bill. For example, if after pattern sensor P1 has traced bill 1 along a slightly tilted line shown by a line a-a, zone address-selecting circuit 4 generates zone addresses ZA corresponding to the zones shown by the hatched squares in the zone address table of zone address-selecting circuit 4. In the zone address table of zone address-selecting circuit 4, numbers 10, 20, 30, 40, and 50 represent track addresses corresponding to track r1, r2, ..., r5 and numbers 01, 02, ..., 08 represent zone numbers corresponding to zones Z1, Z2, ..., Z8.

The zone data read from zone addresses ZA of model map memory 9 is stored in model data memory 10 as model data MD in the order of the zone numbers. Read data RD from read data memory 7 and model data MD from model data memory 10 are compared in comparator circuit 11. If almost all of read data RD and model data MD coincide, bill 1 is regarded as a real bill and if not, bill 1 is regarded as a counterfeit one.

Figure 2 is a side view showing the internal construction of an automatic deposit machine of the type in which bills can be collectively fed. In this machine, the deposition process is carried out in the following way. That is, if a customer collectively feeds a plurality of bills B_1 through fed port 21, bills B_1 are collectively conveyed to standby portion 23 by belts 22, 22'. Bills B_1 are removed one by one from pile B_2 under a standby condition by delivery rollers 24, 25 and separation roller 26 and are supplied by conveyor roller 27 to a discriminating or checking portion 28. After the front and back surface of each bill is checked by discriminating sensors 81, 82 in discriminating or checking portion 28, gate 29 operates depending upon the results. If the bill is a real one, it is guided

by gate 29 to storing portion 30. If it is a counterfeit one, it is guided by gate 29 to return port 31. The black arrows indicate the path for conveying real bills, and the broken arrows indicate the path for conveying counterfeit bills. When the customer presses the confirmation button, a pusher is lowered by motor 32, and real bills B_3 accumulated in storing portion 30 are conveyed to safe 34 from storing portion 30. When the customer presses the cancel button, the bills in storing portion 30 are conveyed collectively to return port 31 through the path indicated by the white arrows and are then conveyed to the customer as denoted by B_4.

Figure 3 illustrates the schematic structure of gate 29 used in the apparatus of Fig. 2. The gate of Fig. 3 comprises gate member 37 fixed to shaft 38, which is rotated by arm 39. Arm 39 is rotatably connected to arm 40 by pin 41 thereof inserted into long hole 42 of arm 40. Arm 40 is fixed to shaft 43 of rotary plunger 44. Shaft 43 is usually energized in a clockwise direction by, for example, a coil spring (not shown), and when rotary plunger 44 is not activated, arm 40 and, thus, arm 39 and gate member 37 are located in the positions shown in Fig. 3. Therefore, a bill conveyed from the direction shown by arrow B between guide rollers 45 is conveyed toward the right side in the direction of arrow C and is guided to return port 31 of Fig. 2. When rotary plunger 44 is activated, arm 40 revolves in a counter clockwise direction as shown by arrow D, and arm 39 and gate member 37 revolve in a clockwise direction as shown by arrow E. Therefore, gate member 37 is located in position opposite to that shown in Fig. 3 with respect to a line connecting the center of shaft 38 and the center of shaft 43. Therefore, a bill conveyed from the direction shown by arrow B between guide rollers 45 is conveyed toward the left side in the direction of arrow F and is guided to storing portion 30 of the apparatus of Fig. 2.

Thus, a bill is processed in different ways depending

upon the results of discrimination in the discriminating portion 28 of the apparatus of Fig. 2. Operation of discriminating portion 28 is described below. While a bill is being conveyed by transfer rollers 49, 49', its thickness is determined by thickness sensor 35, consisting of, for example, microswitches, so as to ascertain whether the bills are being conveyed one by one or whether two or more bills are being conveyed togethers. Then the positions of both the front end and rear end of the bill being conveyed at a predetermined speed are detected by optical sensors 36, 36' (T1 or T2) in order to discriminate the size of the bill in the direction of movement on the basis of the conveyance time. When it is discriminated that the size of the bill is not within the allowable limit, the bill is determined as being counterfeit and is returned to return port 31. If the size appears to be proper, the patterns on the front and back surface are then discriminated by discriminating sensors 81, 82 so as to determine the kind of bill.

The bill-discriminating portion is usually constructed as shown in Fig. 4, in which narrow gaps G, G' are defined between guides 47, 47' on both sides of the passage and edges of conveyed bill b so that bill b will not tilt or will not deviate sideways, thereby constantly maintaining the position of the predetermined region that is read by the discriminating sensors. Allowance, however, must be made for a small degree of deviation. To effect discrimination in spite of a small degree of deviation, therefore, the patterns of the bill must be discriminated by utilizing regions of relatively simple patterns P. Therefore, it is difficult to carry out discrimination with a high accuracy, and discrimination is often erroneously rendered depending upon the degree of damage of or contamination of the bill. In the case of small size bills, furthermore, it is difficult to accurately restrict the position. Hatched regions 48 of bill b are scanned and read by discriminating sensors 81, 82.

If the passage is strictly defined, furthermore, the bill always runs through the same passage no matter how many times it is fed. Therefore, a counterfeit bill can be continually fed until it is accepted by the discriminating portion. Further, if complicated patterns P of bill b are discriminated in order to increase the accuracy of discrimination, all of the contents of the reference pattern memory must be read and discriminated. Therefore, more time is required for the discrimination process.

Figure 5 illustrates an example of a discriminating portion used in a device for discriminating bills according to the present invention. In Fig. 5, reference numeral 49 denotes upper conveyor rollers of the upper side of the passage as shown in Fig. 2, and reference numerals 47, 47' denote paper guides that correspond to guides 47, 47' of Fig. 4. As in the case of Fig. 2, the bill is conveyed by conveyor rollers 27 to a portion between guides 47 and 47' and is then conveyed through the discriminating portion by conveyor rollers 49 and a lower conveyer roller (not shown). The discriminating portion has two lower surface discriminating sensors 81 and two upper surface discriminating sensors 82 which magnetically read patterns on both the front and back surface of the bill. Further, two sensors T_1 , T_2 are arrayed in the widthwise direction of the passage at distance d so as to detect the amount of tilt. Position sensors W_1 , W_2 are arrayed along the passage, i.e., on the right and left sides of the discriminating portion through which the bill passes. Position sensors W_1 , W_2 determine the position of bill b at both the right and left sides in the widthwise direction of the passage and consist of a plurality of sensor elements s1, s2, --- that are arrayed a predetermined distance from each other in the widthwise direction of the passage. To more accurately determine the position of the bill the number of sensor elements s1, s2, --- should be increased. However, if it is difficult to array sensor elements s1 to s16 in a single row in the widthwise direction of the passage, they

are arrayed in two rows being tilted from the direction of conveyance of the bill as shown in Fig. 5. When bill b passes over position sensors W_1 , W_2 , the positions of both edges or ends e_1 , e_2 of the bill and the length of the bill are determined in the discriminating portion depending upon which sensor elements among sensor elements s1, s2, --- are shielded by ends e_1 , e_2 in the lengthwise direction of the bill. The kind of bill can be determined by the length of the bill. Therefore, in a case where the apparatus is designed to treat 500 yen to 10,000 yen bills (Japanese monetary units), the distance between outermost sensor elements s1 and s1 of position sensors W_1 and W_2 is greater than the lateral size of the 10,000 yen bill, and the distance between innermost sensor elements s16 and s16 of position sensors W_1 and W_2 is selected to be less than the lateral size of the 500 yen bill. Symbols L_1 , L_2 denote optical discriminating sensors which optically read the patterns of the bill and determine the patterns on the basis of the density of the color component. In the diagrammed embodiment, the light-emitting elements and the light-receiving elements are located above the conveyed bill and utilize the light reflected from the bill. However, the light-emitting elements and the light--receiving elements may be so disposed that light passes therethrough, to detect the pattern utilizing the transmitted light.

Among these sensors, position sensors W_1 , W_2 and sensors T_1 , T_2 determine the position of the bill, the amount of tilt of the bill, and the kind of bill, and descriminating sensors 81, 82 and optical sensors L_1 , L_2 read the patterns of the bill. The amount of tilt (angle of tilt) of bills delivered one by one is detected on the basis of the time difference in which position of edge e_3 of each bill is detected by sensors T_1 , T_2 which determine the amount of tilt. Sensors T_1 and T_2 and sensors L_1 and L_2 are usually disposed within the area of outermost sensor elements s1 of position sensors W_1 and W_2.

Figure 6A and Fig. 6B illustrate the structure of a magnetic head assembly used as discriminating sensor 81 or 82. The magnetic head assembly comprises magnetic head 50, which slightly protrudes from an opening of guide plate 51 along which a bill is conveyed. Magnetic head 50 is fixed to first member 52, which is pivotally connected to a shaft 53 connected to second member 54. The revolution angle of first member 52 and, therefor, the protrusion of head 50, can be adjusted by screw bolt 55. Second member 54 is joined to third member 56 by screw bolt 57 and coil spring 58 shown by the dotted line. The angle between second member 54 and third member 56 and, therefore, the contact between magnetic head 50 and the bill is adjusted by screw bolt 59 and two screw bolts (not shown) screwed into second member 54. Third member 56 is attached to support member 60 by screw bolt 61 and coil spring 62 shown by the dotted line. The angle between third member 56 and support member 60 and, therefore, the contact between magnetic head 50 and the bill is adjusted by screw bolts 63, 64, and 65. Support member 60 is fixed to guide plate 51 by spot welding.

Figure 7A through 7C and Figs. 8A and 8B illustrate the structure of a light-emitting unit used in aforementioned position sensor W_1 or W_2. Figures 7A through 7C illustrate a sensor board assembly in which a plurality of light-emitting diodes (LED) 67 are attached to printed circuit board 68 via spacer 69. Spacer 69 is made, for example, of soft resin so that the position of each of light-emitting diodes 67 can be adjusted. Figures 8A and 8B illustrate a complete light-emitting unit in which the sensor board assembly is attached to holder member 70 made of transparent resin by using four screw bolts 71 through 74. Holding members 75 and 76, which are made of opaque resin, are inserted between holder member 70 and printed circuit board 68 and between holder member 70 and spacer 69. Holding members 75 and 76 sandwitch light--emitting diodes 67 so that light-emitting diodes 67 are

disposed in a straight line.

Position sensor W_1 or W_2 is composed of the light--emitting unit mentioned above and a light-receiving unit which has the same structure as the light-emitting unit except that light-emitting diodes 67 thereof are replaced by photosensitive elements such as photo diodes or photo transistors. The light-emitting unit and the light--receiving unit are disposed on either side of the passage of the bill so that the light-emitting diodes and the light-sensitive elements face each other.

Figures 9A and 9B illustrate the structure of amount--of-tilt sensor T1 or T2, i.e., a skew sensor. The amount--of-tilt sensor of these figures comprises light-emitting unit 78 and light-receiving unit 79 disposed on either side of the passage between upper guide plate 80 and lower guide plate 96. Light-emitting unit 78 comprises light-emitting diode 95 attached to printed circuit board 83. Printed circuit board 83 is fixed to support member 84 via holder 85 by using screw bolt 86. Support member 84 is welded to lower guide plate 96. Transparent dust cover 87 is inserted between holer 85 and lower guide plate 96. Light-receiving unit 79 comprises light-sensitive element 88, such as a photo diode, attached to printed circuit board 89, which is fixed to support member 90 via holder 91 by screw botl 92. Support member 90 is welded to upper guide plate 80. Transparent dust cover 93 is inserted between holder 91 and upper guide plate 80. Light-focusing lens 94 is arranged between dust cover 93 and light--sensitive element 88 and within holder 91.

Figures 10A and 10B illustrate the structure of reflection-type photo discriminating sensor L_1 or L_2. The sensor of these figures comprises lamp 97 as a light--emitting element which is attached aslant to holder 98 fixed to upper guide plate 99 by support member 100 welded to upper guide plate 99. The sensor also comprises photo diode 101 as a light-receiving element attached to printed circuit board 102, which is fixed to holder 98 by screw

bolt 103. Under photo diode 101, filter element 104, focusing lens 105, and dust cover 106, made of transparent material, are arranged. Light emitted from lamp 97 is radiated to a bill being conveyed along the passage defined by upper guide plate 99 and lower guide plate 107 through dust cover 106. Light reflected from the bill is received by photo diode 101 through dust cover 106, focusing lens 105, and filter element 104. Filter element 104 attenuates the red component of light reflected from the bill in order to equalize the spectrum distribution of lamp 97.

Figure 11 illustrates the detailed structure of the bill-discriminating portion used in a bill-discriminating apparatus according to the present invention. The bill--discriminating portion comprises upper guide plate 110 attached to a pair of side frames 111 and 112 corresponding to guides 47 and 47' of Fig. 5. Magnetic discriminating sensors 82 shown in Figs. 6A and 6B, photo-discriminating sensors L_1 and L_2 shown in Figs. 10A and 10B, and the light-receiving units of position sensors W_1 and W_2 are attached to upper guide plate 110. Under the light--receiving units of position sensors W_1 and W_2 , the light-emitting units thereof (not shown) are arranged and are fixed to the lower guide plate (not shown). The light receiving units of amount-of-tilt sensors T1 and T2 shown in Figs. 9A and 9B are attached. Under the light-receiving units of amount-of-tilt sensors T1 and T2, the light--emitting units thereof are arranged and are fixed to the lower guide plate. In Fig. 11, a bill is conveyed by conveyor rollers 113 from the direction shown by arrow A to the passage defined by upper guide plate 110 and the lower guide plate, and the position, the amount-of-tilt, and the patterns of the bill are sensed by the above-mentioned various sensors.

While bill b is being conveyed through the thus constructed discriminating portion, the pattern of bill b is read by discriminating sensors 81, 82. Namely, if

regions 46, 46' of the bill indicated by the hatched zones in bill b shown in Fig. 5 pass under discriminating sensors 82, the data read from the regions is discriminated in relation to reference patterns which have been stored beforehand in the memories. With regard to the lower surface of bill b, furthermore, the patterns are read by lower discriminating sensors 81 and are discriminated in relation to the reference patterns.

The reference patterns are stored in the memory in the form of model maps as shown in Figs. 12A and 12B. The model map of Fig. 12A corresponds to reading region 46' of Fig. 5, and the model map of Fig. 12B corresponds to reading region 46 of Fig. 5. Model maps are prepared on the basis of data, for example, "1", "0" obtained in accordance with the patterns of the regions corresponding to reading regions 46,46', of a real bill. In this case, width X of the bill in the horizontal direction (as shown in Figure 5) is divided into 15 zones in the direction of conveyance as shown in Figs. 12A and 12B, and the length of reading regions 46, 46' is divided into ten tracks in direction Y (lateral direction of the bill). Namely, a total of 150 small sections constitute pattern data that corresponds to the pattern of a real bill and is stored in a memory such as a ROM. Therefore, the data read by discriminating sensor 82 at the side of guide 47 is discriminated in relation to the model map of Fig. 12B, and the data read by discriminating sensor 82 at the side of guide 47' is discriminated in relation to the model map of Fig. 12A.

When bill b is conveyed along the passage, the data need only be discriminated over zones 1 to 15 of a particular track. In practice, however, the bill often becomes tilted, as indicated by dot-dash line b' in Fig. 5. In such an event, the introduced data is compared with the data of small sections in the model map in the tilted direction, as indicated by the chain line, in response to the amount of tilt (angle of tilt). The amount of tilt determined by sensors T_1 , T_2 and the data related to the

position of the bill, the data being obtained by sensors W_1, W_2, are used for determining the sections from which the reference pattern data is to be read. The reference patterns will also differ, i.e., the contents of the model map will also differ, depending upon the kind of bill. Therefore, the model maps to be used are selected depending upon the size of the bill that is conveyed. For this purpose, size data obtained from sensors W_1, W_2 is used.

Figure 13 is a flow chart which illustrates the operation for selecting small sections of a model map that is to be compared with the data read from the bill. First, as explained above with reference to Fig. 2, the thickness is determined by thickness sensor 35. When it is confirmed that the bill has arrived at sensor T_1 or T_2, the width of the bill i.e. its dimension in the direction of conveyance is determined from the time required for the bill to pass between sensors T_1, T_2 which are used to detect the amount of tilt. When the width is within the allowable range, the bill is regarded as being a real one. Thereafter, from the amount of tilt of the bill determined by sensors T_1, T_2, the data for correcting the track is sent to model map memory 121 and to optical model map memories 122, 122'. Model map memory 121 and optical model map memories 122, 122' are further furnished with data for correcting the track, this data being obtained from the data related to the position of the bill in the widthwise direction of the passage determined by position sensors W_1, W_2. The positions of the tracks in the model map are corrected based upon the data related to the position of the bill for correcting the tracks. Optical model map memory 122' stores the model map which is compared with the data read by reflection-type optical sensors L_1, L_2. When optical sensors of the light-transmission type are used, the data is compared with the reference pattern stored in optical model map memory 122.

Figure 14 is a flow chart which illustrates in detail the operation for correcting the track position depending

upon the amount of tilt. If the amount of tilt is determined as being too great, the bill is not discriminated and is returned to the return port. If the amount of tilt is within the allowable limit, the correction coefficient is set from the amount of tilt, and the value for correcting the track in the reference pattern in the model map is determined. When the bill tilts as indicated by chain lines b' in Fig. 5, the position of chain line b' and the angle of tilt are determined so as to select small sections in the model map of Figs. 12A and 12B on the basis of the track-correction value that is set based upon the amount of tilt. The kind of bill is temporarily determined depending upon th size of the bill detected by sensors W_1, W_2. In this case, a 10,000 yen bill has the greatest length and a 500 yen bill has the smallest length.

However, when the bill which has arrived at the discriminating portion is smaller than the value set for the 500 yen bill or is larger than the value set for the 10,000 yen bill, it is determined as having an improper size and is conveyed to the return port. Depending upon the result of discrimination of the bill in regard to size, the model map of the bill to be used is read out. The position of the track of the model map is then set, and the pattern data read by discriminating sensors 82, 82 is discriminated in relation to the thus set track. When they appear to be in agreement, the kind of bill is finally determined.

Such processing operation is realized by the processing circuits of Figs. 15 and 16. In Fig. 15, reference numeral 123 denotes a gate circuit, 124 denotes a timer, 125 denotes a unit for converting the amount of tilt, and 126 denotes a circuit for switching the discriminating pattern. Gate circuit 123 receives discriminating signals when bill edge e_3 is detected by sensors T_1, T_2, which determine the amount of tilt. Operation of timer 124 is started in response to a signal from either sensor T_1 or

sensor T_2 , depending on which one receives the input first, and is stopped in response to signal from the sensor which later detects the front edge of the bill. The quantity of this time difference is converted into the tilt value (angle of tilt) by unit 125 for converting the amount of tilt and is sent to a discriminating pattern switching circuit 126. The amount of tilt is also sent to comparator circuit 127 and is compared with a value set in unit 128 which sets the allowable limit for the amount of tilt. When the set value is exceeded, the bill is determined as being excessively tilted and is returned to the curstomer.

Position detecting circuits 129, 129' receive detection signals from sensors W_1 , W_2. The position of the bill in the widthwise direction of the passage is determined depending on which sensor among sensor elements s1 to s16 in sensors W_1 , W_2 detects the edge of the bill. Position data is introduced into length detecting unit 130 to determine the length. The value of the length is then sent to bill comparators 131a, 131b, 131c, --- to determined the kind of bill. For instance, if the value of the length corresponds to the preset size of the 10,000 yen bill, bill comparator 131a produces a signal which indicates that the bill is a 10,000 yen bill and the signal is then supplied to discriminating pattern switching circuit 126. When the value of the length does not correspond to any of the preset sizes, signal NG, which indicates an improper size, is produced from gate circuit 133 through gate circuit 132. Further, track detecting circuit 134 receives data from at least one position detecting circuit 129' so as to determine the position of the conveyed bill in relation to discriminating sensors 81, 82 and L_1 , L_2. It is then determined which track on the model map should be read out and used. The thus found data is then sent to discriminating pattern switching circuit 126.

In effect, discriminating pattern switching circuit 126 is supplied with data relating to the kind of

bill, the amount of tilt, and the position of the track. On the basis of this data, therefore, a model map of the corresponding kind of bill is selected from the model map memories provided for all kinds of bills. Then which track of the tracks 1 to 10 in Figs. 12A and 12B should be read out and used is specified as address data of the memory. Similarly, the angle of tilt of chain lines f in Figs. 12A and 12B is calculated from the tilt value, and sections, i.e., addresses of the sections traversed by chain line f are specified from the angle of chain line f and from the position of the above-mentioned track. The pattern data of addresses of small sections traversed by chain line f are then sent to a true/ false discriminating circuit 135, which is supplied with data read by discriminating sensors 82, 82 and by optical sensors L_1, L_2. The pattern data is compared with a reference pattern produced from the model map. When the pattern data and the reference pattern are in agreement, the kind of bill temporarily determined by bill comparators 131a, 131b, --- is confirmed. Depending upon the degree of contamination of the bill, in this case, the pattern data of the addresses traversed by chain line f in the model map may not be completely in agreement. Therefore, if the pattern data of the addresses is in agreement within the allowable limit, the bill is regarded as having been discriminated. When the bill fails to be discriminated, signal NG indicating that the bill is not a real bill is produced by gate 133. In practice, in the case of a 10,000 yen bill, which is the largest in size, the amount of tilt is small, and discrimination is effected within four tracks. As the size of the bill decrease, the amount of tilt increases. Therefore, discrimination is effected within an increased number of tracks. For example, in the case of a 5,000 yen bill, discrimination is effected within eight tracks, and in the case of a 500 yen bill, discrimination is effected within ten tracks.

Reference numeral 136 denotes a zone dividing circuit

which divides the time required for sensors T_1, T_2 to sense the front and rear edges of the bill into 15 sections in order to divide the data which is read into 15 sections according to the number of zones. That is, as shown in Fig. 16, the signal produced by sensor T_1 is amplified through amplifier 137 and is shaped by waveform shaping circuit 138. Then the time through which the wave-shaped signal is produced is equally divided by counter 139, which performs the counting operation upon receipt of the signals supplied by timer 141 via gate circuit 140, thereby obtaining a train consisting of 15 pulses. In this case, if the conveyed bill is a 10,000 yen bill having the greatest size, all of the 15 sections divided from the data are compared with all of the 15 zones in the model map. In the case of a 5,000 yen bill in which the reference pattern has only 14 zones, 14 pulses are produced due to conveyance of the bill and constitute a pulse train. Similarly, 13 pulses are produced in the case of a 1,000 yen bill, and 12 pulses are produced in the case of a 500 yen bill. In the case of a 500 yen bill, which has the smallest size, the pattern is compared over 12 zones. The thus divided pulse trains are supplied into true/false discriminating circuit 135, whereby the data read out is compared with the pattern data in the model map in the direction of the zones. In a system in which the bill is always guided along a guide of only one side of the passage, the position sensor needs only be provided on one side.

According to the present invention as mentioned above, the position of the bill being conveyed and the amount of tilt are determined to select a model map of a corresponding kind of bill from the memory in which reference pattern data is stored and the data of addresses corresponding to the conveyance condition is read in order to effect discrimination. Therefore, the position of the bill being conveyed, unlike in the conventional art, need not be strictly restricted and the pattern can be discriminated with increased precision even in the case of small size

bills. Unlike the conventional art, furthermore, the discriminating sensors need not be installed symmetrically in relation to the center line of the bill. The pattern need not be discriminated for all of the zones in the model map. It need be checked only by selecting and reading a minimum number of addresses based upon the data related to the position of the bill being conveyed and the data related to the amount of tilt. Accordingly, the discriminating time can be greatly reduced, and the discrimination process can be performed at a high speed.

CLAIMS

1. A bank note checking apparatus for determining the denomination and/or checking the validity of a bank note by comparing patterns read from the bank note with a reference pattern, comprising means to convey bank notes (1), means (P_1) for reading patterns from a bank note (1) as it is conveyed past the means (P_1), one or more sensors (T_1, T_2, W_1, W_2) for determining a physical condition of the bank note during conveyance, means (4, 10) for generating an appropriate reference pattern from stored standard patterns (9) in accordance with the sensed physical condition of the bank note (1), and means (11) for comparing the patterns read from the bank note (1) by the means (P_1) for reading patterns with the generated reference patterns, thereby determining the validity and/or the denomination of the bank note (1).

2. An apparatus according to claim 1, in which the one or more sensors for determining a physical condition of the bank note (1) comprises at least one position sensor (W_1, W_2) located beside the means to convey the bank notes (1) sensing the position of an edge of the bank note (1) to determine its size, and skew sensing means (T_1, T_2) for determining the amount of tilt of the bank note (1).

3. An apparatus according to claim 2, which includes two position sensors (W_1, W_2) located on opposite sides of the path of the bank notes (1) through the apparatus.

4. An apparatus according to claim 2 or 3, in which the or each of the position sensors (W_1, W_2) comprises a plurality of sensor elements (S_1 to S_{16}) arranged in one or more rows inclined to or perpen-

dicular to the direction of conveyance of the bank note (1).

5. An apparatus according to claim 4, in which the means (P_1) for reading patterns is located within the area of the outermost sensor elements of the position sensors.

6. An apparatus according to any one of claims 2 to 5, in which the skew sensing means comprises two sensors (T_1,T_2) spaced apart in a direction transverse to the direction of conveyance of the bank notes (1)

7. An apparatus according to claim 6, in which the two sensors (T_1 and T_2) are optical sensors.

8. An apparatus according to claim 7, in which the two optical sensors of the skew sensing means are also used as the means for reading patterns.

9. An apparatus according to claim 3 or any one of claims 4 to 8 when dependent upon claim 3, which does not include mechanical guides to define the location or orientation of the bank note (1) being conveyed.

10. An apparatus according to any one of claims 1 to 8, in which means are provided to locate one edge of the bank notes (1) as they are conveyed.

11. An apparatus according to any one of the preceding claims, in which means for generating an appropriate reference patterns from stored standard patterns in accordance with the sensed physical condition of the bank note (1) comprises a model map memory (9) which stores standard pattern data of a number of adjacent zones of one or more valid bank notes, and zone address-selecting means (4) which is fed with an output from the one or more sensors (T_1,T_2,W_1,W_2) and which supplies address data to the model map memory (9) to read out the reference pattern data corresponding to the physical condition of the bank note (1).

12. An apparatus according to claim 11, in which the zone address-selecting means (4) generates the address data on the basis of information from the sensors (T_1,T_2,W_1,W_2) concerning one or more of the following: the amount of tilt of the bank note (1), the location of the bank note (1) in the direction transverse to the directing conveyance, the speed of conveyance of the bank note (1), and the length and hence the denomination of the bank note (1).

13. An apparatus according to claim 11 or 12, in which the denomination of the bank note is temporarily determined on the basis of its sensed length, which at least partly determines the reference pattern, and then the validity of the bank note (1) is determined by comparing the patterns read from the bank note (1) with the selected reference pattern .

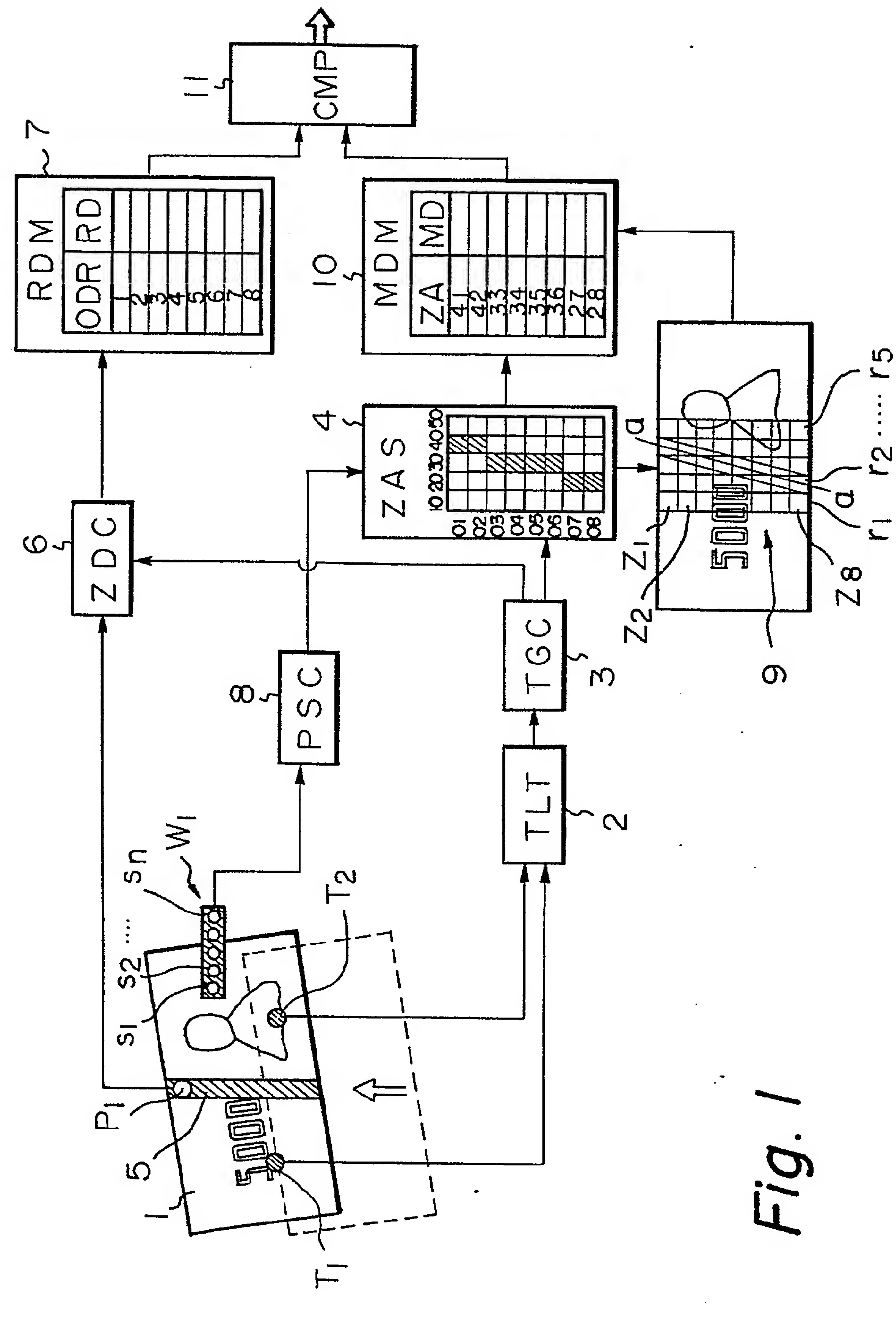

CMP
11
RDM
ODR
RD
7
MDM
ZA
MD
10
ZAS
4
ZDC
6
PSC
8
TGC
3
TLT
2
5000
W1
S1
S2
Sn
T1
T2
P1
5
1
9
Z1
Z2
Z8
r1
r2
r5
a

Fig. 1

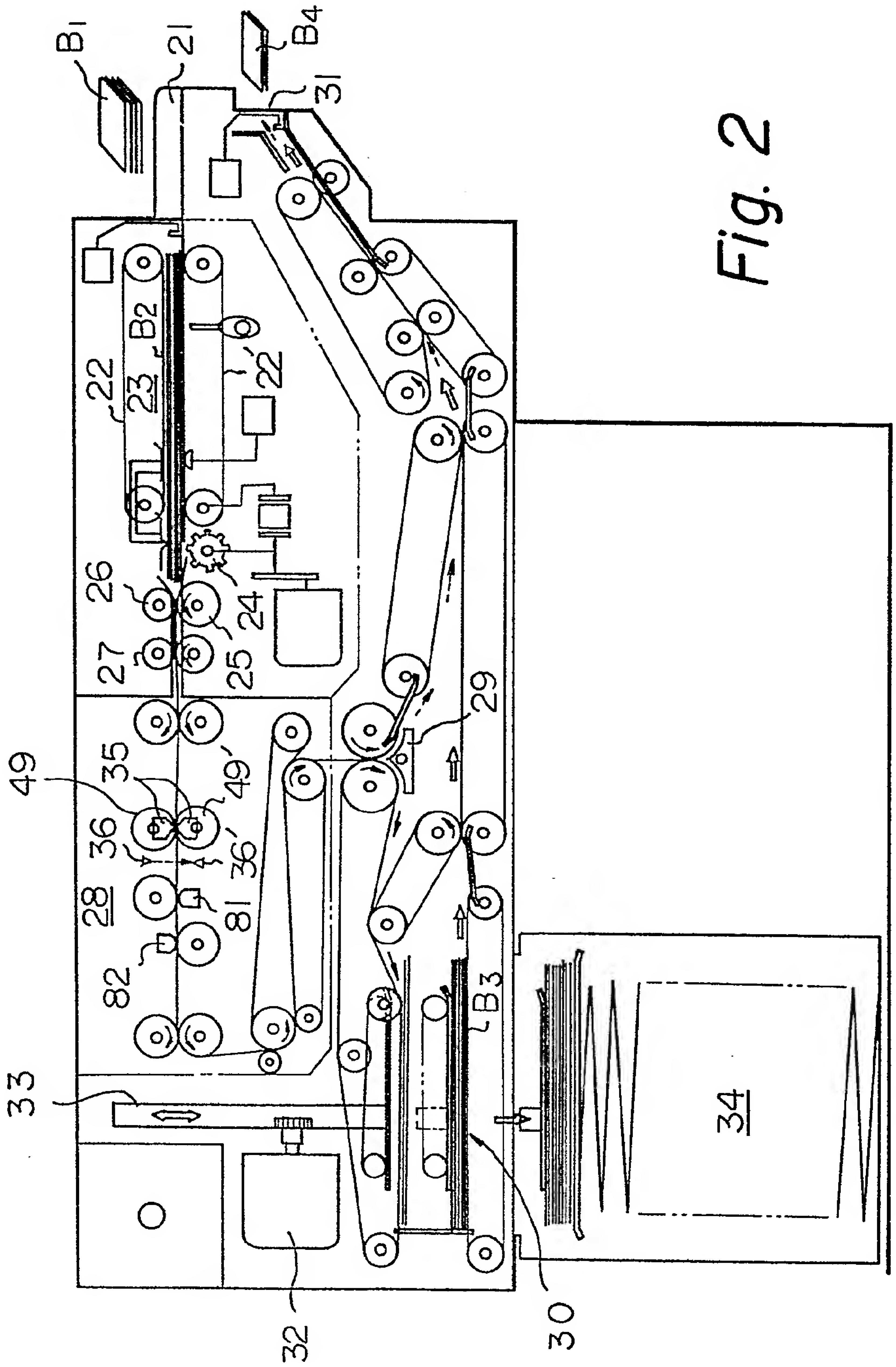

B1
21
B4
31
22
23
B2
22'
26
24
27
25
49
35
49'
36
36'
28
81
82
33
29
B3
34
32
30

Fig. 2

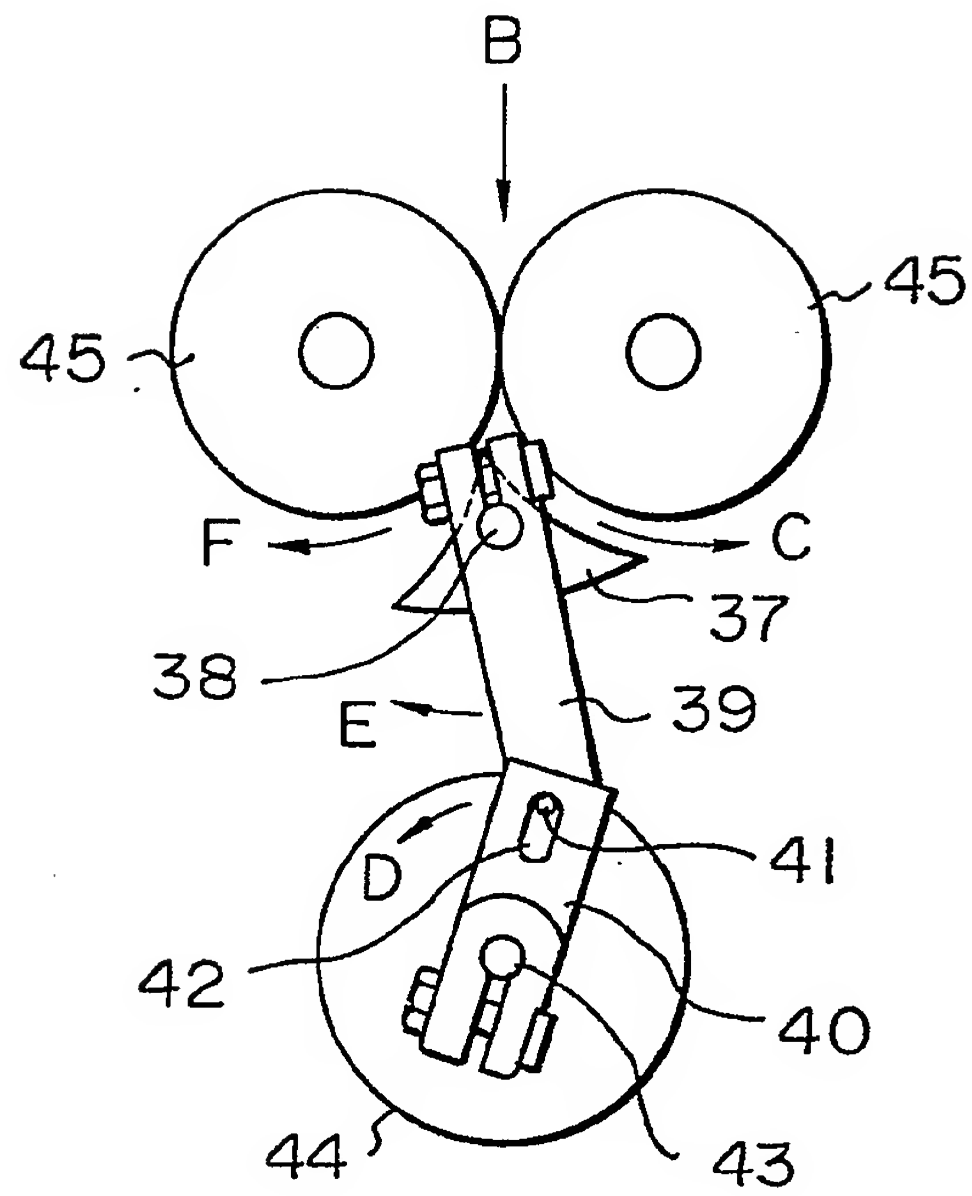


Fig. 3

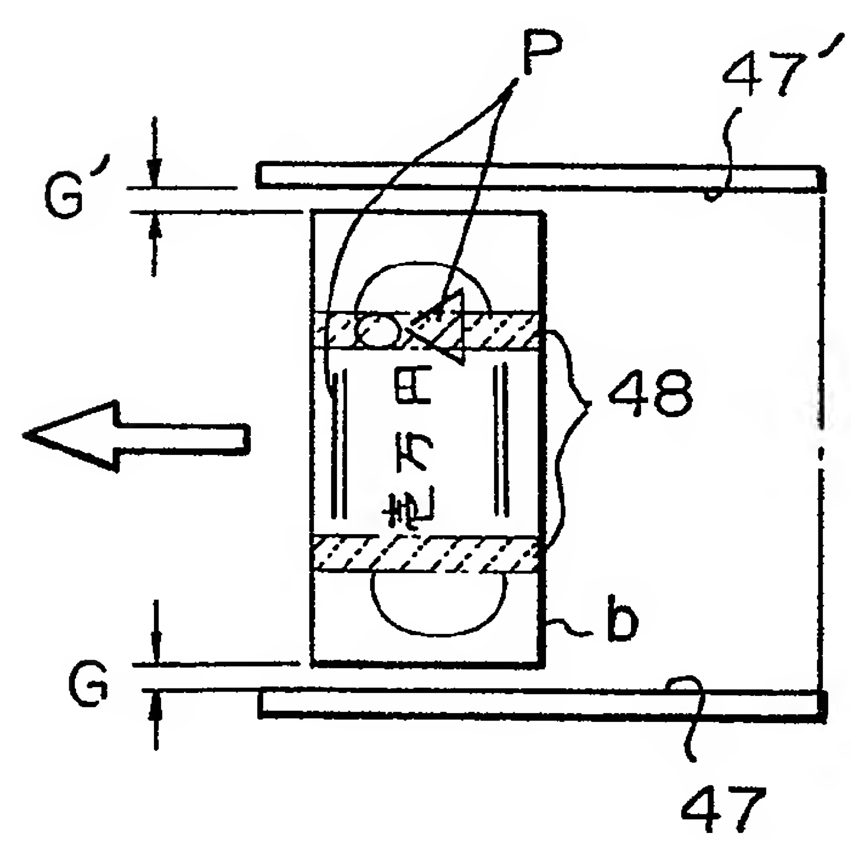


Fig. 4

Fig. 5

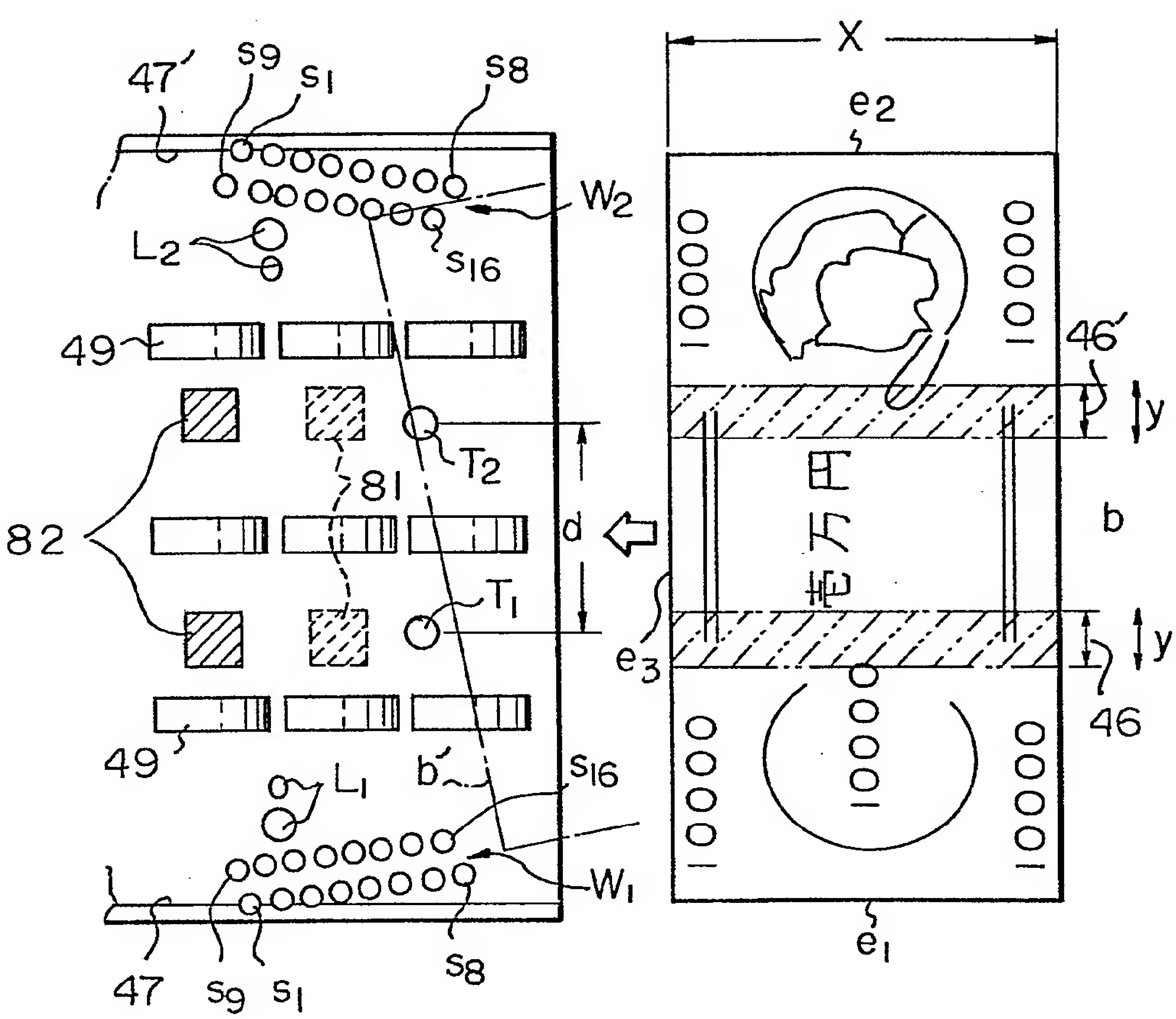

47'
s9
s1
s8
W2
L2
s16
49
T2
81
82
d
T1
49
L1
b'
s16
W1
47
s9
s1
s8
X
e2
10000
46'
y
b
e3
46
y
e1

Fig. 6A

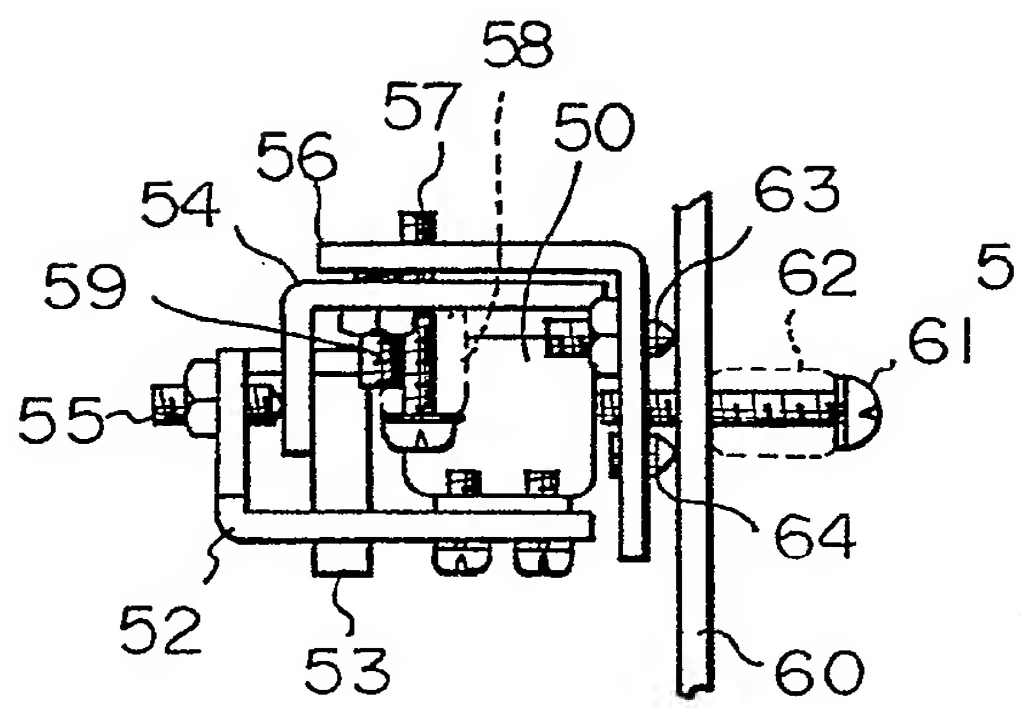


Fig. 6B

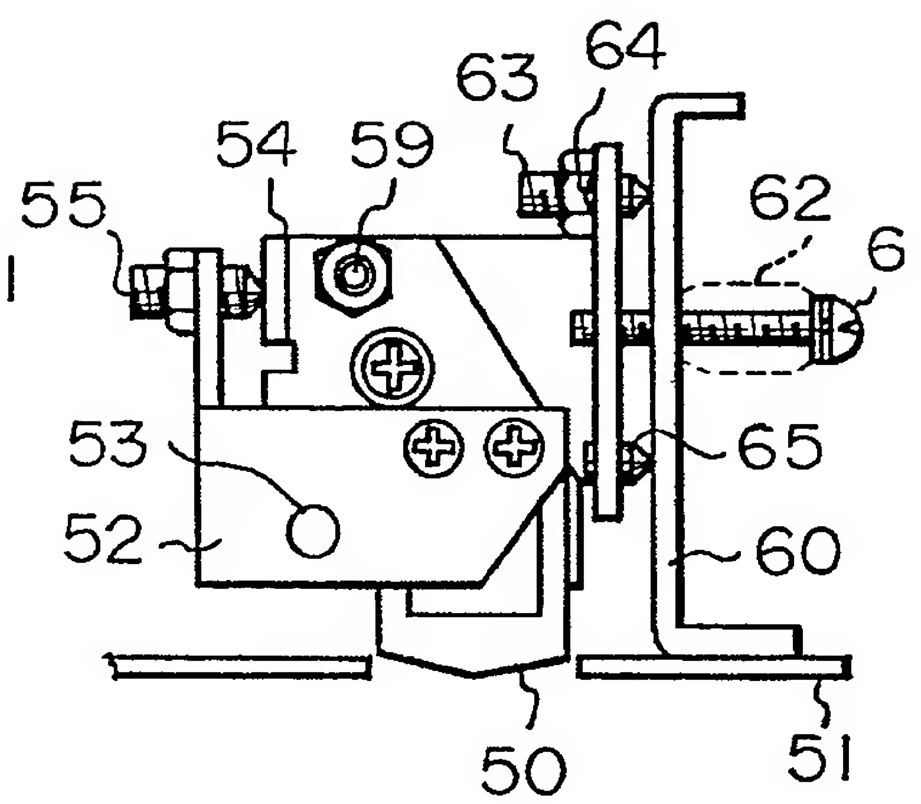


Fig. 7A

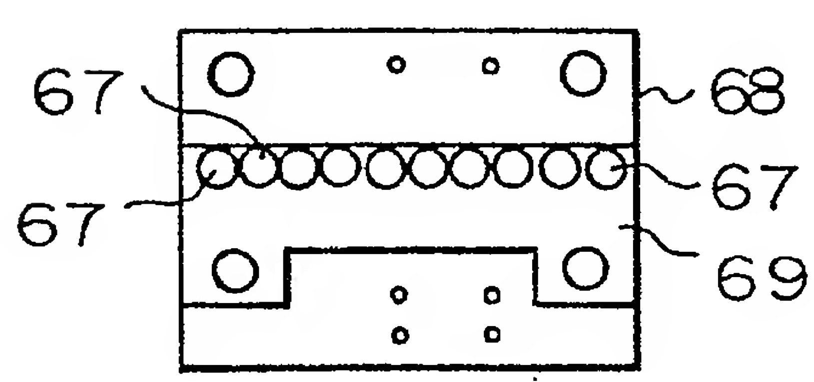


Fig. 7B

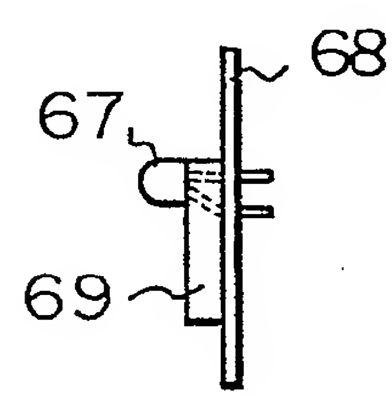


Fig. 7C

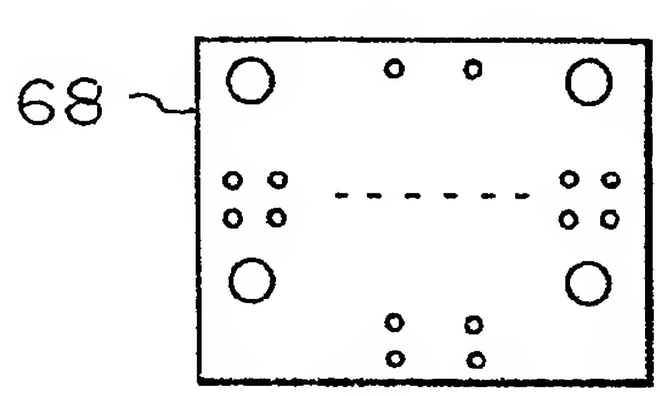


Fig. 8A

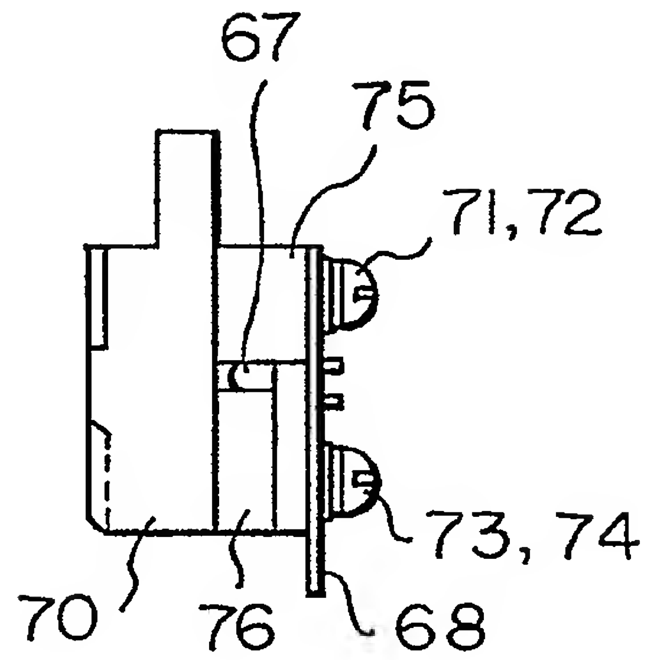


Fig. 8B

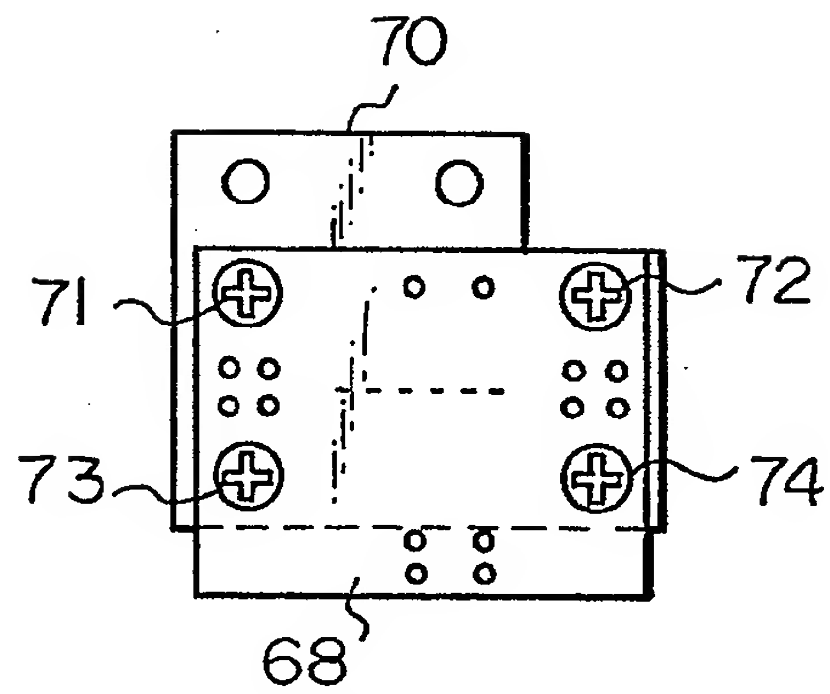


Fig. 9A

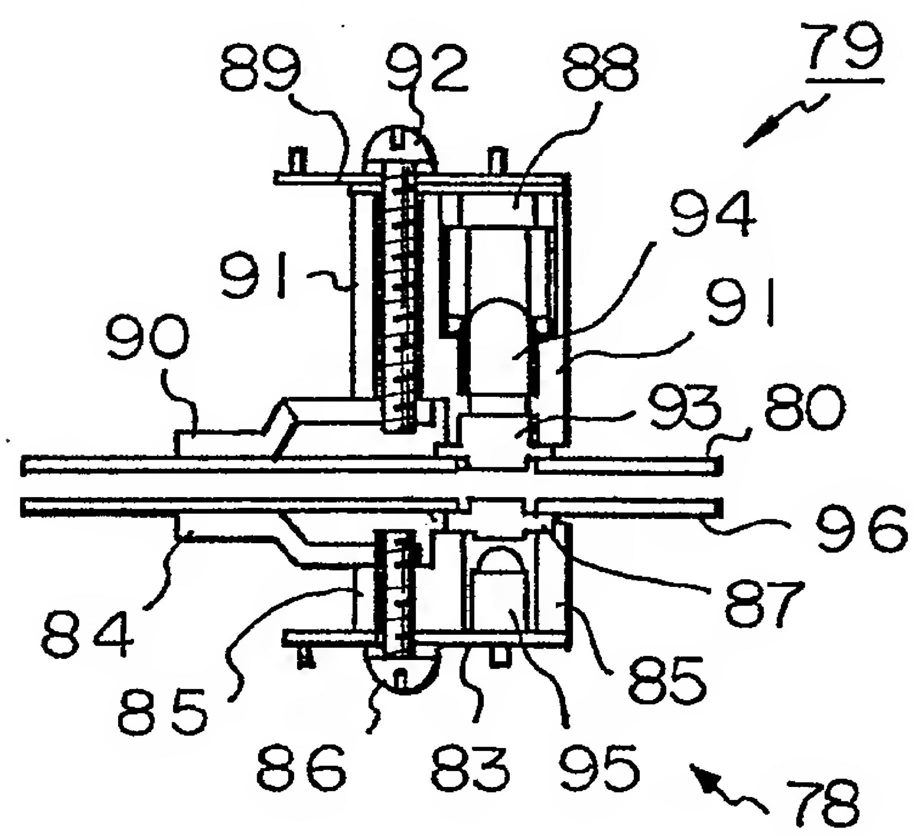


Fig. 9B

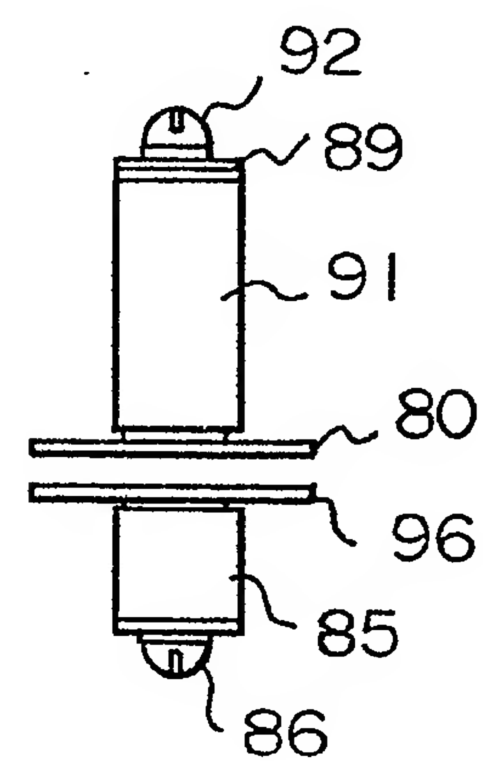


Fig. 10A

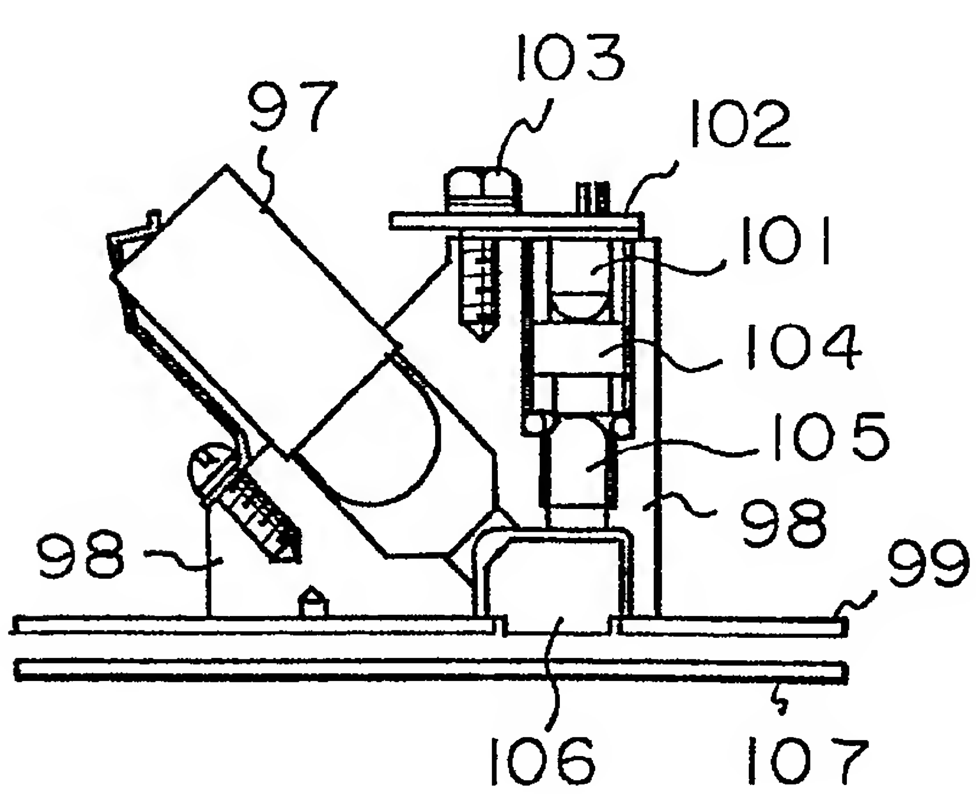


Fig. 10B

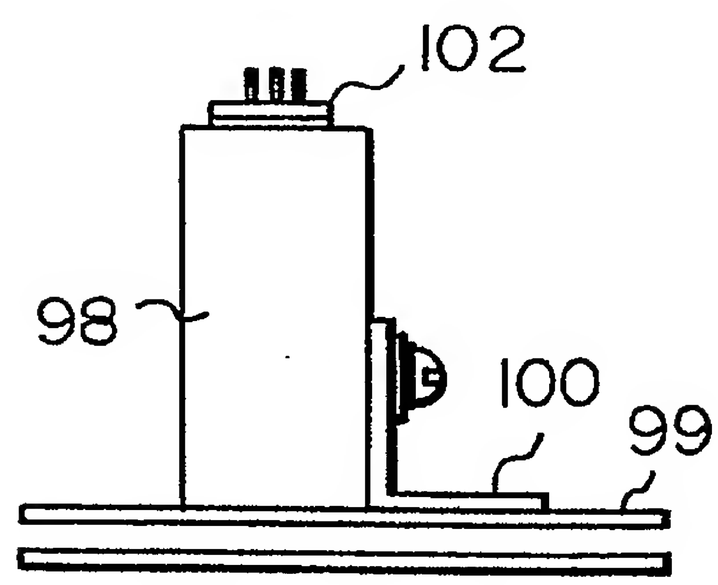


Fig. 11

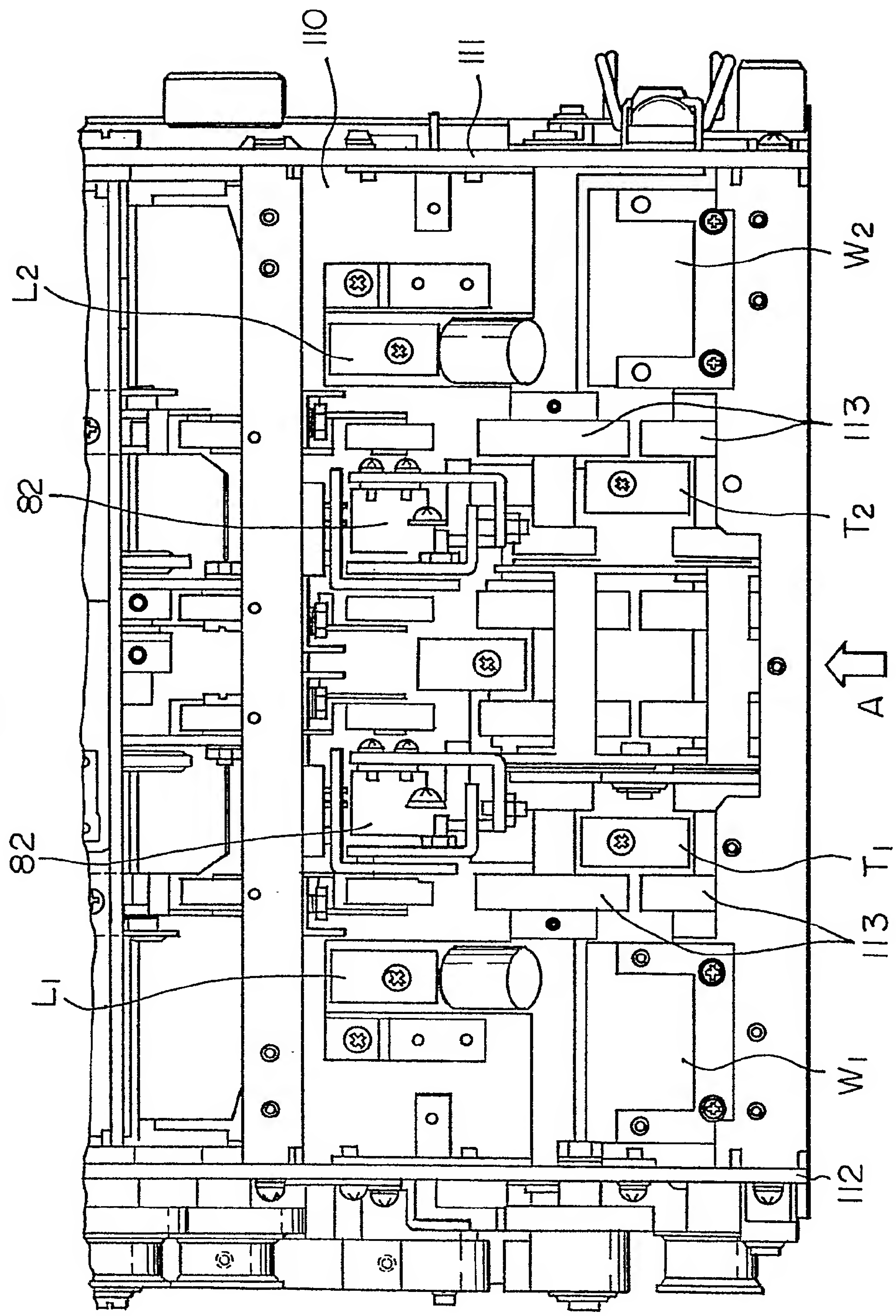


Fig. 12A

→ ZONE

X

TRACK \ ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	1	1	1	1	0	0	0	0	1	1	1	0	0	1
2	0	1	1	1	1	0	0	0	0	0	1	1	1	1	0
3	0	0	1	0	0	0	1	1	1	1	1	1	1	1	0
4	1	1	0	1	0	0	0	0	0	0	1	1	1	0	1
5	0	1	1	1	0	0	1	0	1	0	0	0	0	0	1
6	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1
7	0	1	0	0	1	0	0	1	1	1	1	0	1	0	0
8	0	0	1	0	1	1	0	1	1	0	1	0	1	0	0
9	0	1	1	1	0	1	1	0	0	1	1	1	1	0	0
10	0	1	0	0	1	0	0	1	0	0	0	0	1	1	0

y

f

Fig. 12B

→ ZONE

X

TRACK \ ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	1	1	0	0	0	1	1	0	1	0	1	1	1	0
2	1	1	0	0	1	1	0	1	0	0	0	1	1	0	1
3	1	1	0	0	1	1	0	0	1	1	0	0	0	1	1
4	1	1	0	1	1	1	0	0	0	0	1	0	0	0	1
5	0	1	1	1	0	0	1	0	1	0	0	0	0	0	1
6	0	0	0	0	0	0	0	1	1	1	0	1	1	0	1
7	0	0	1	1	0	0	0	1	0	1	1	0	0	1	1
8	1	0	0	1	0	0	0	1	0	1	1	1	1	1	1
9	1	1	0	1	1	0	0	1	0	1	1	1	0	0	1
10	1	1	0	0	0	1	1	0	0	0	0	1	1	0	1

y

f

Fig. 13

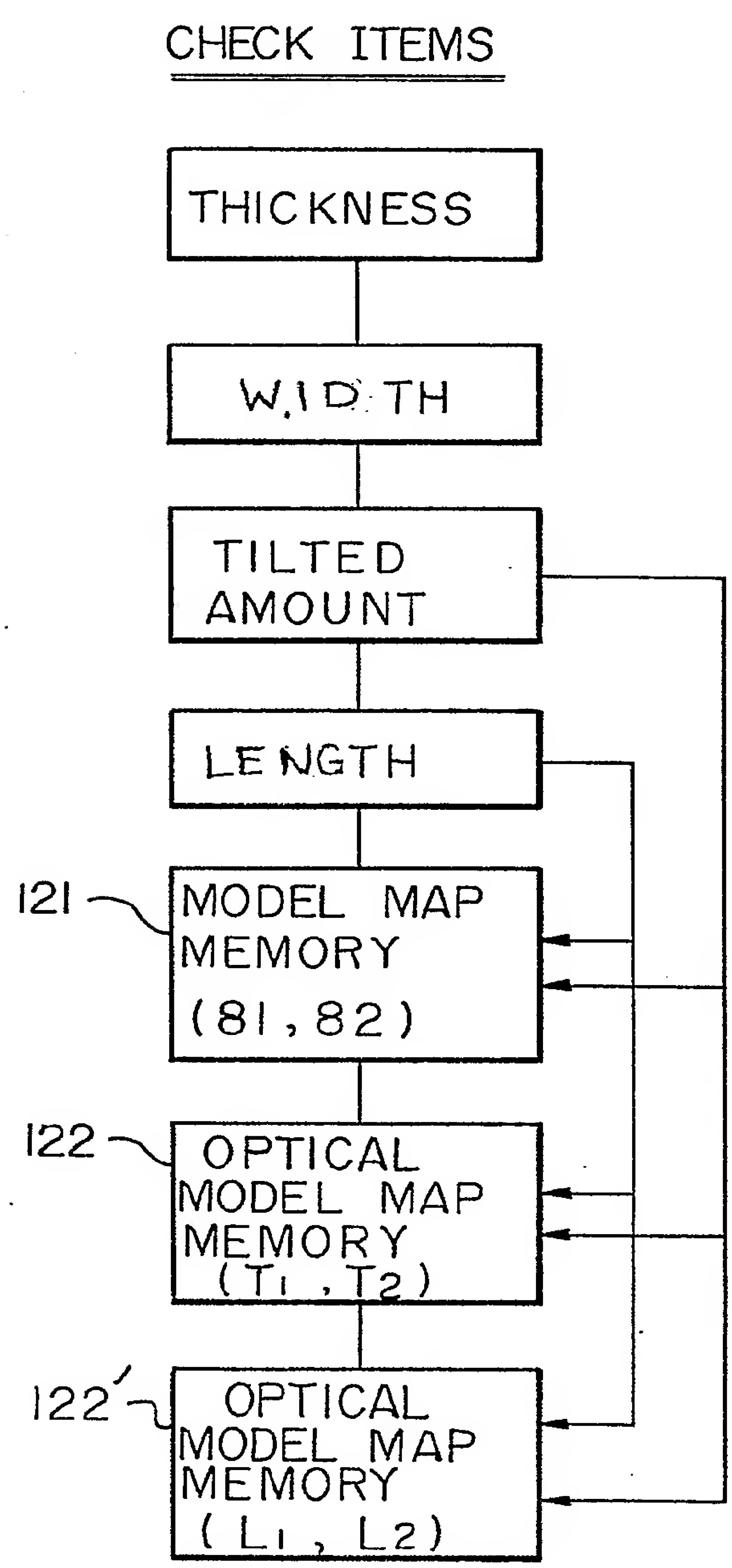

CHECK ITEMS
THICKNESS
WIDTH
TILTED AMOUNT
LENGTH
121
MODEL MAP MEMORY (81, 82)
122
OPTICAL MODEL MAP MEMORY (T1, T2)
122'
OPTICAL MODEL MAP MEMORY (L1, L2)

Fig. 14

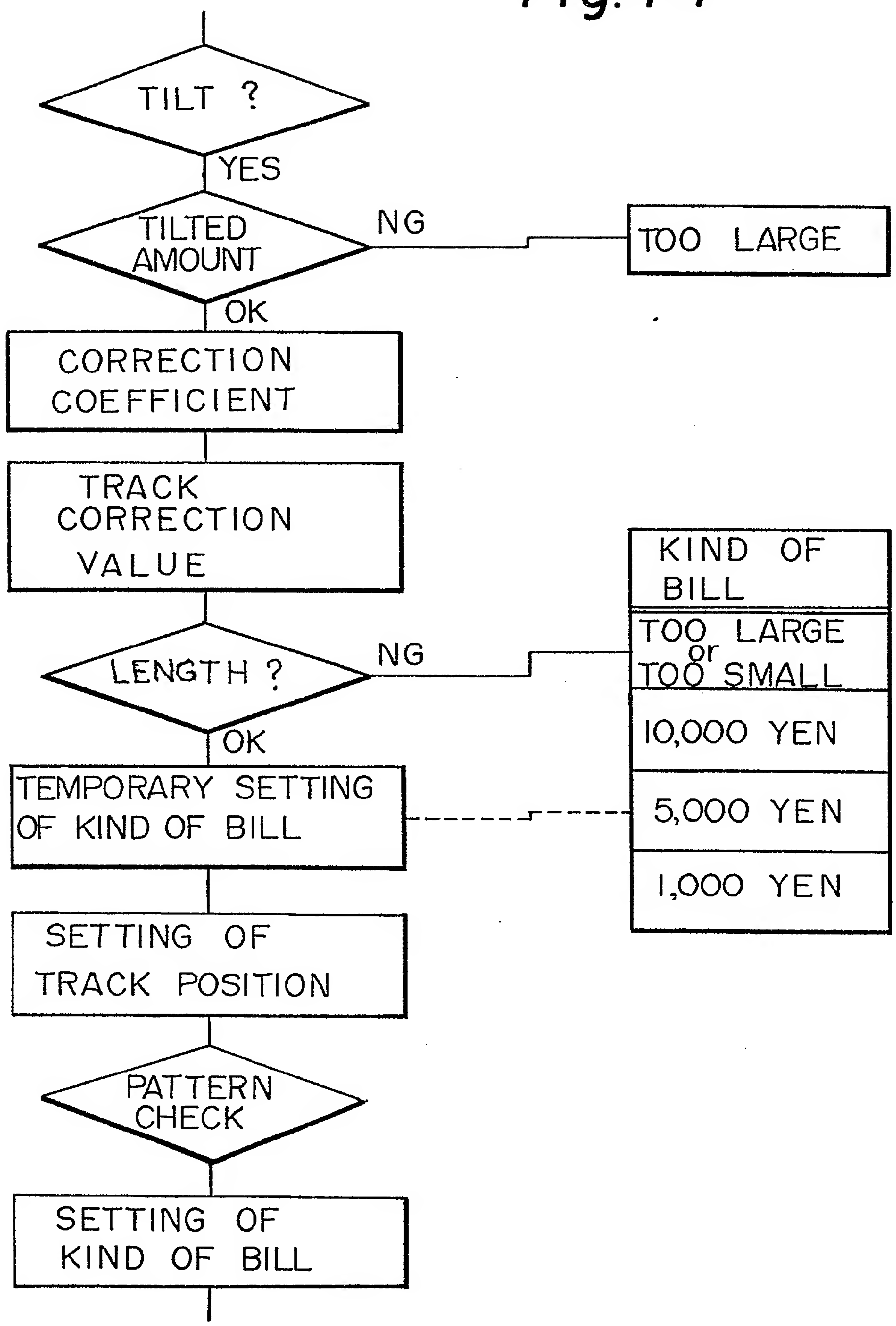

TILT ?
YES
TILTED AMOUNT
NG
TOO LARGE
OK
CORRECTION COEFFICIENT
TRACK CORRECTION VALUE
KIND OF BILL
LENGTH ?
NG
TOO LARGE or TOO SMALL
10,000 YEN
OK
TEMPORARY SETTING OF KIND OF BILL
5,000 YEN
1,000 YEN
SETTING OF TRACK POSITION
PATTERN CHECK
SETTING OF KIND OF BILL

Fig. 15 A

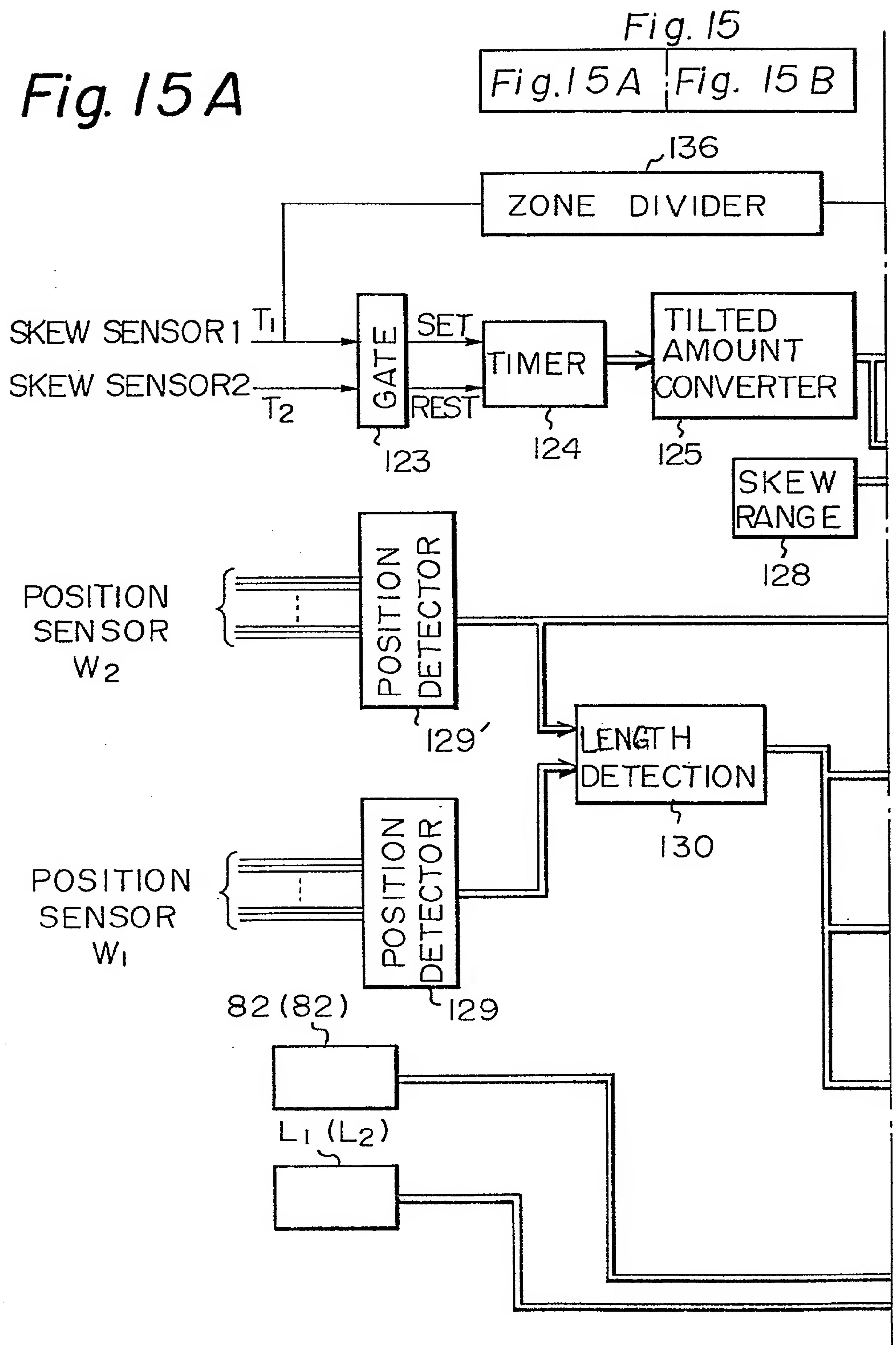
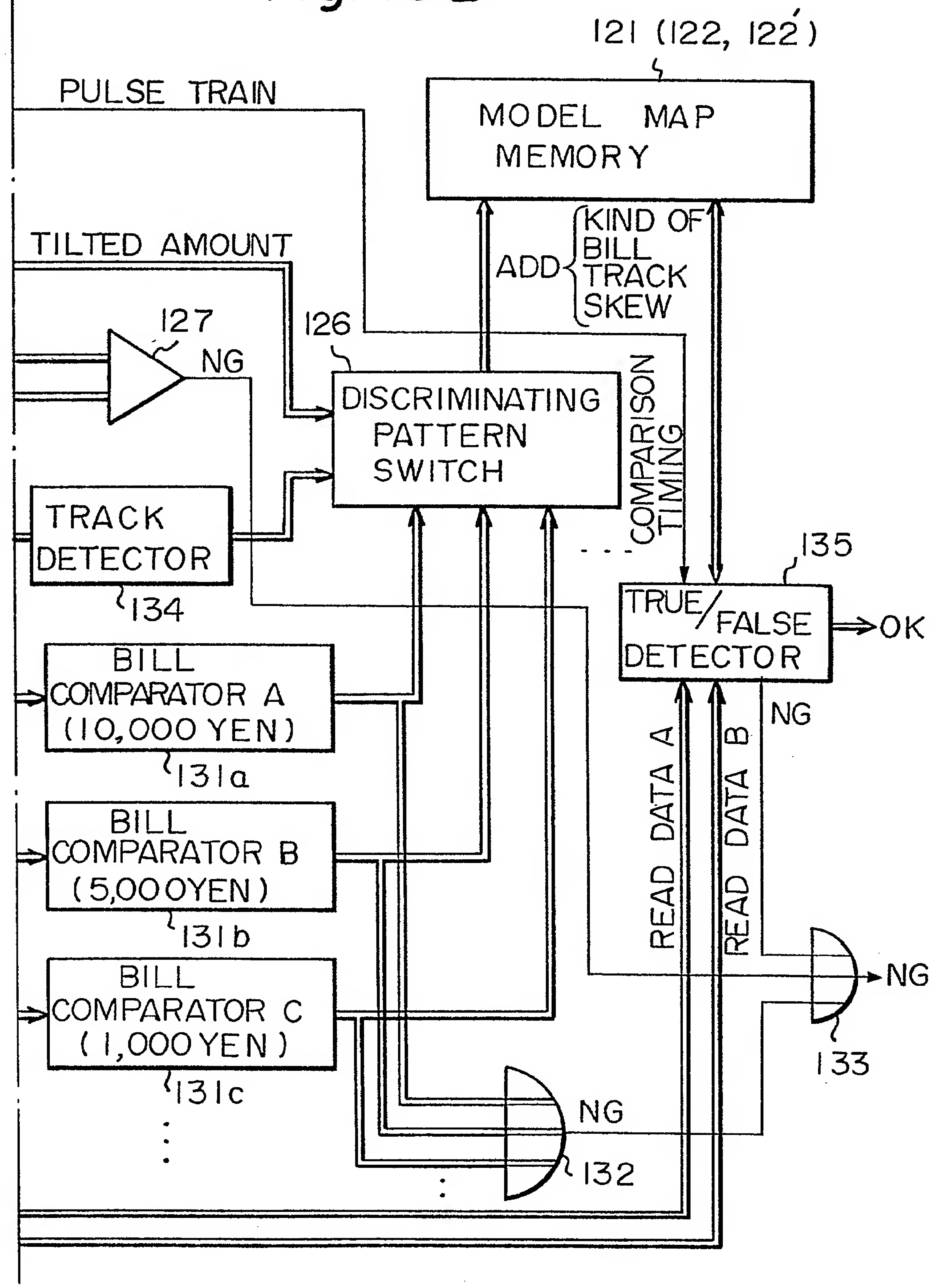


Fig. 15
Fig. 15 A
Fig. 15 B
136
ZONE DIVIDER
SKEW SENSOR 1
SKEW SENSOR 2
T1
T2
GATE
SET
REST
TIMER
TILTED AMOUNT CONVERTER
123
124
125
SKEW RANGE
128
POSITION SENSOR W2
POSITION DETECTOR
129'
LENGTH DETECTION
130
POSITION SENSOR W1
POSITION DETECTOR
129
82 (82)
L1 (L2)

Fig. 15B


121 (122, 122')
MODEL MAP MEMORY
PULSE TRAIN
TILTED AMOUNT
ADD
KIND OF BILL
TRACK
SKEW
127
NG
126
DISCRIMINATING PATTERN SWITCH
COMPARISON TIMING
TRACK DETECTOR
134
135
TRUE/FALSE DETECTOR
OK
BILL COMPARATOR A (10,000 YEN)
131a
NG
READ DATA A
READ DATA B
BILL COMPARATOR B (5,000YEN)
131b
NG
BILL COMPARATOR C (1,000YEN)
131c
133
NG
132

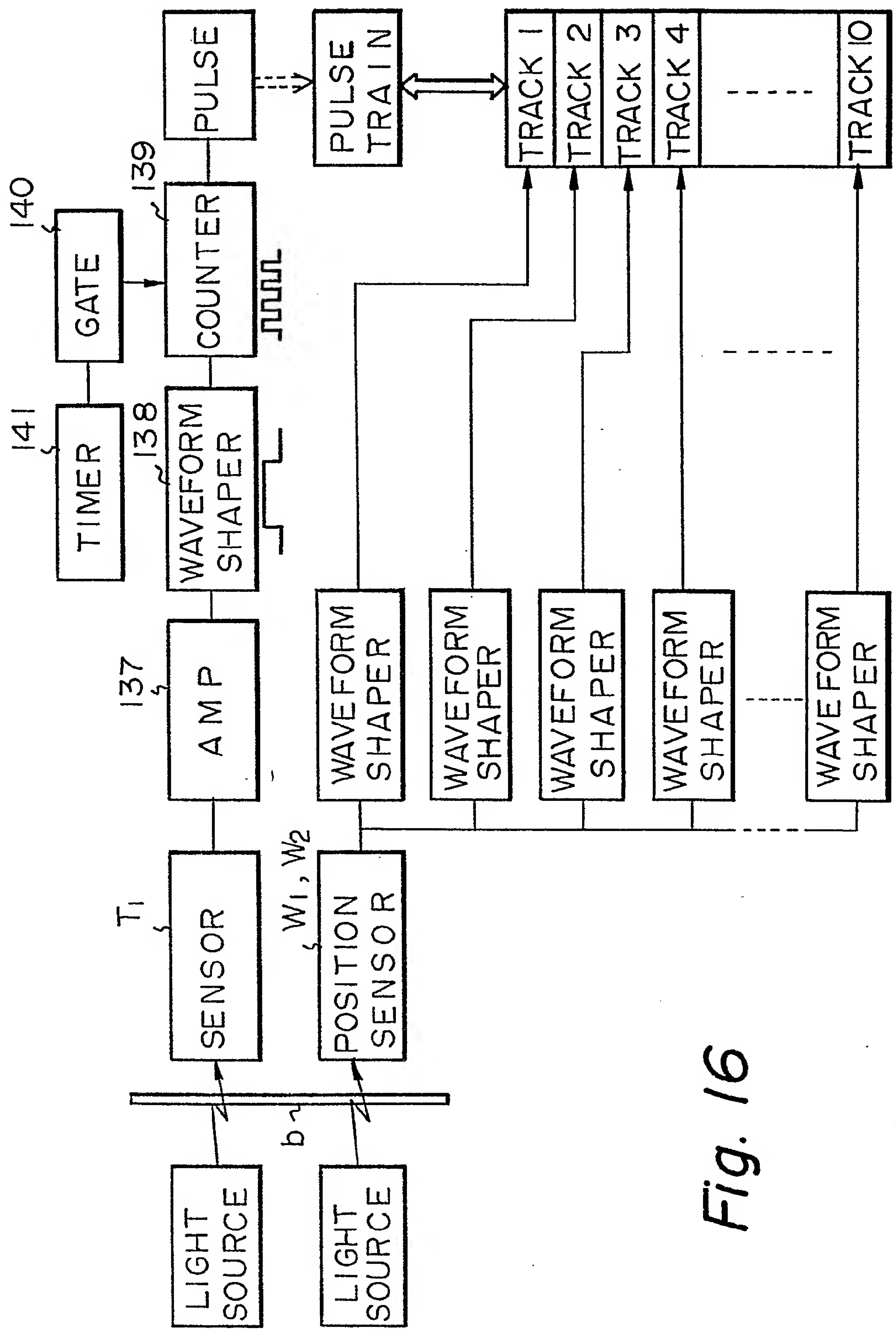

LIGHT SOURCE
LIGHT SOURCE
b
SENSOR
T1
POSITION SENSOR
W1, W2
AMP
137
WAVEFORM SHAPER
138
TIMER
141
GATE
140
COUNTER
139
PULSE
PULSE TRAIN
WAVEFORM SHAPER
WAVEFORM SHAPER
WAVEFORM SHAPER
WAVEFORM SHAPER
WAVEFORM SHAPER
TRACK 1
TRACK 2
TRACK 3
TRACK 4
TRACK 10

Fig. 16